

Appendix A: Glossary of Terms

Adiabatic

A boundary condition that assumes a perfectly insulated or a symmetric condition.

Adjacent polygon

A polygon that shares a common side with another polygon.

ASHRAE

The American Society for Heating, Refrigerating and Air-Conditioning Engineers, Inc.

ASHRAE summer conditions

Environmental conditions, used to determine Solar Heat Gain boundary conditions, with the following characteristics:

- Exterior Temperature: 31.7°C
- Room Temperature: 23.9°C
- Wind Speed on Exterior Surface: 3.4 m/sec, windward
- Direct Solar Radiation: 783.0 W/m²

ASHRAE winter conditions

Environmental conditions, used to determine U-factor boundary conditions, with the following characteristics:

- Exterior Temperature: -17.8°C,
- Room Temperature: 21.1°C,
- Wind Speed on Exterior Surface: 6.7 m/sec, windward
- Direct Solar Radiation: 0.0 W/m².

Aspect ratio

The dimension perpendicular to the heat flow (vertical for horizontal heat flow) divided by the dimension parallel to the heat flow (horizontal for horizontal heat flow). This value is used to determine the effective conductivity in frame cavities.

Assembly drawings

Drawings that show many separate parts put together. These drawings often show deformable pieces that overlap. When creating a THERM model

from an assembly drawing the user must turn these overlapping pieces into polygons with no voids or overlaps.

Autoconvert

An option when importing DXF files into THERM that allows closed polylines and curves to be turned into polygons.

AutoLISP programs

Programs created to automate commands in AutoCAD™ that can be used to improve the applicability of a DXF file for the THERM autoconvert feature.

Bad Points

Two points that are closer than 0.1 mm are considered "bad points", because they should actually be the same point. These bad points are marked with red circles when the boundary conditions are drawn. If they are defects in the drawing they should be fixed, but if they are areas of fine detail they can be ignored. The bad points can be cleared using the **Draw/Clear Bad Points** menu choice. View the red circles is controlled using the **View/Bad Points** menu choice.

Bitmap file

An file format that THERM can use as an underlay to be traced. Bitmap files do not contain information about lines and vertices, so THERM cannot snap to vertices as it can with a DXF underlay. Bitmap files sometimes distort the dimensions of the cross section and should be used with care.

Black Body Radiation

Electro-magnetic radiation governed by the Stefan Boltzman law:

$$q = \sigma T^4$$

The sun is a source of black body radiation. The emissivity of a surface is a measure of how a surface compares to a black body, which is defined with an emissivity of 1.0.

Blocking surfaces

When calculating radiation heat transfer between the model and a radiation enclosure, THERM automatically calculates the view factor between all surfaces. The view factor calculation takes into account which surfaces block the view between other surfaces. By default, all surfaces of a radiation enclosure are blocking surfaces, meaning that they can *potentially* block the view between two other surfaces. Optionally, the blocking surface option can be turned off for any surface. Turning off the blocking surface option will speed the view factor calculation process, but should only be done for surfaces that will never block the view between two other surfaces.

Boundary conditions

The properties and/or relationships that define the edges of the model are called boundary conditions. For the steady state energy equation solved in THERM, the boundary conditions either specify the heat flux and/or the temperature. Environmental conditions, film coefficients, surface emissivities, radiation view factors, and thermal conductivities are used to determine the boundary conditions of the model. The default boundary condition in THERM is an adiabatic or perfectly insulating boundary.

Boundary segment

A boundary segment is the line segment between any two points on the boundary (or edge) of the model. Boundary segments must be assigned boundary conditions and may be tagged to be included in the U-factor calculations.

CAD

Computer Aided Design. A category of computer drafting programs that can create a DXF file that can be used as an underlay in THERM.

Cavities

There are two types of cavities mentioned in the THERM manual. A glazing cavity is the gas filled gap between glazing layers in a multilayer glazing system. A frame cavity is an air filled cavity that occurs in window frames, especially in extruded vinyl and aluminum frames.

Cavity height

The total height of the glazing system cavity, including two edge regions and a center of glass region. This value is a necessary input for the Condensation Index calculation.

Cavity Model

The cavity model refers to one of several options for modeling frame cavities in THERM. The various cavity models have different methods of approximating non-rectangular cavity geometry, effective conductivity and radiative heat transfer.

CEN

The standard body of the European Community analogous to ASTM.

CEN radiation model

The simplified radiation model used with the CEN frame cavity models. This model approximates a frame cavity as a rectangular cavity with isothermal walls. The radiative conductance (hr) uses a view factor (F) for a rectangular section and a linearized Stephan Boltzman law:

$$h_r = E \cdot F \cdot 4\sigma \cdot T_{avg}^3$$

$$E = (\varepsilon_1^{-1} + \varepsilon_2^{-1} - 1)^{-1}$$

$$F = \frac{1}{2} \left(1 + \sqrt{1 + (L/H)^2} - L/H \right)$$

Where T is Temperature, ε is emissivity, L is the cavity dimension in the direction parallel to the heat flux and H is the cavity dimension in the direction perpendicular to the heat flux.

Center-of-glass

The region in a glazing system where the frame and spacer effects are negligible and one-dimensional heat transfer occurs. The thermal properties for the center-of-glass region are determined in the WINDOW program.

Condensation Index

Refers to the calculation procedure that uses local film coefficients and the radiation enclosure model to obtain local temperatures that are more accurate than those obtained using the effective conductivity method for glazing systems.

Conduction

Heat transfer resulting from a temperature difference between adjacent objects governed by the thermal conductivity.

Conductivity

A measure of the rate at which heat flows through a material. Materials that are good conductors of electricity (i.e. metals) are usually good conductors of thermal energy as well and have a high thermal conductivity. An insulating material is a poor conductor of thermal energy and has a low thermal conductivity. Units are Btu/hr-ft-F, Btu-in/hr-ft²-F or W/m-K.

Constant heat flux magnitude

Heat flux is vector quantity, meaning that the heat flux at any point in the model has both a magnitude and a direction. The Constant Heat Flux Magnitude result only indicates the magnitude of the heat flux, which is useful in identifying thermal bridges and evaluating thermal breaks.

Convection

Heat transfer resulting from gas movement caused either by a temperature gradient or by an incident wind.

Convection correlations

Convection heat transfer is treated approximately in THERM using correlations developed from experimental and computational research.

These correlations are used to determine the effective conductivity in frame cavities. They provide results that are a function of the thermal properties, geometry, and temperature difference in the cavity.

Cross section geometry

A two dimensional view cut through a three dimensional object, represented in THERM by polygons. This geometry is derived from a DXF file or a dimensioned drawing.

Cursor sticky distance

The area of influence of the cursor relative to a vertex. If the mouse is clicked when the drawing cursor is within this distance from a vertex, the cursor will "stick" to the vertex. This helps prevent voids and overlaps from being unintentionally created in the drawing. The sticky distance is 3mm at 100% scale, which is about half the length of one side of the drawing cross hair. This distance is fixed, so as you zoom in, it becomes smaller with respect to the detail of the drawing. If you are having trouble with the program snapping to the wrong vertices, try zooming in on the area of interest which effectively reduces the sticky distance.

Curve fit model

The simplified radiation model associated with the NFRC and User Defined frame cavity models that uses the length (L), height (H) and average absolute temperature (T_{avg}) to determine the approximate radiative conductance (h_r)⁽¹⁶⁾:

$$h_r = \exp(1.53 - 0.194 * L / H) * (T_{avg} / 273)^3$$

Deformable pieces

Components of a cross section, such as glazing stops, glazing tape and weather-stripping, which will change size and shape (i.e., deform) when they are assembled into a real product. They are often drawn in their undeformed state in assembly drawings, resulting in overlapping regions. Because there can be no overlapping regions or voids in a THERM cross section, these objects should be modeled as they will actually occur in the real product rather than how they appear in the assembly drawing.

Detailed radiation model

The detailed radiation model uses an element to element view factor method (see Appendix C for more information) to determine the radiant exchange between every element in the enclosure it is applied to. The detailed radiation model accounts for the temperature and emittance of these elements.

Dialog box

A THERM program window that displays information and allows user input. For example, if the user selects the **File/Open** menu choice, a small

program window, or dialog box, opens, allowing the user to choose the file to be opened.

Dimensioned drawing

A representation that includes all the dimensions needed to represent an object as a cross section in THERM.

DXF file

An export file format from a CAD program that can be used as an underlay in THERM. THERM can preferentially snap to the vertices in a DXF file and can convert the closed polylines into polygons.

DXFOUT command

The command used in a CAD program to create a DXF file.

Edge effects

The two dimensional heat transfer that occurs in the glazing system due to the thermal bridging effects of the spacer and frame.

Effective conductivity

A method that converts the convection and radiation effects of a volume of gas into a conductance that is combined with the thermal conductivity to model the gas volume as if it were a solid.

Emissivity

The ratio of the actual emission of radiation by an object to the emission of a black body at the same temperature.

Entities

An object such as a line, circle, arc or polyline treated as a single element in a CAD program in order to simplify creation, manipulation and modification of those objects.

Environmental conditions

The conditions that define the environment surrounding the model from which the boundary conditions are derived (see ASHRAE summer conditions and ASHRAE winter conditions for examples).

External Radiation Enclosure

A THERM material type used to model a space through which radiation heat exchange takes place between the model and other external surfaces. Each of these external surfaces can have its own temperature and emissivity.

Finite element mesh

A collection of non-overlapping three and four sided elements upon which the finite element analysis is performed. The mesh is generated automatically by THERM based on the geometry of the model. Subsequent adaptation of the mesh based on the heat flux in the model can be achieved using the error estimator option.

Finite-element analysis

The numerical method used in THERM to solve the two dimensional energy equation. The equation is set up on each element of the finite element mesh and then a solution for each element that minimizes the global error of the entire mesh is obtained by solving a matrix of related variables.

Floating point tolerance

The minimum distance between points in THERM, which is set at 0.01 mm. Points that are closer together than this distance are merged together.

Flux

See heat flux.

Frame cavities

See Cavities.

FRAME™ F30 file

A file created by the FRAME 3.0 program developed by Enermodal Engineering Ltd.

Glazing cavity

See Cavities.

Glazing layers

Transparent layers, such as glass and acrylic, combined with spacers and fill gases, to create glazing systems.

Glazing system

In THERM, a glazing system imported from the WINDOW4 computer program. It is a series of polygons that represent the thermal properties, heat transfer characteristics, and boundary conditions of a glazing unit. A sample WINDOW4 glazing system library is provided with THERM. Additional glazing systems can be created using the WINDOW4 program.

Heat flux

Heat flux is the vector quantity determined from the thermal conductivity and the local temperature gradient surrounding a node on the finite element mesh.

Heat transfer analysis

Heat transfer analysis is a term applied to the solution of the energy equation in its many forms. There are three main modes of heat transport: conduction, convection and radiation. All three of these modes are modeled in THERM.

Heat-flux vectors

Heat flux is a vector quantity that has a magnitude and a direction, resulting from the finite element analysis. These vectors are determined for every node in the finite element mesh. They are a function of the thermal conductivity and the local temperature gradient. The heat flux vector plot shows one heat flux vector for each element. This vector is determined by integrating the heat flux over the entire element. Its magnitude is a function of the heat flux and also the size of the element. The heat flux vector plot gives a qualitative representation of the direction of heat flux through the cross section.

Horizontal heat flow

The default assumption in frame cavity models is that heat flow is occurring largely between the two vertical sides of the cavity (or its equivalent rectangle) and thus the flow is horizontal. This heat flow is driven by a temperature difference between these two sides. Other possible models are vertical flow up and vertical flow down.

Isotherms

Lines of constant temperature.

Keff

See Effective Conductivity.

Local film coefficients

Local convective film coefficients vary as a function of position. They provide improved accuracy in the calculation of local temperatures and are used in the Condensation Index Model.

Local temperatures

Temperatures at a specific location in contrast to temperatures averaged over an area.

Material properties

The thermal conductivity and emissivity characteristics of a material. For example, the material properties for a frame cavity are the geometry, the emissivity, the thermal properties of the gas, and the temperature difference across the cavity.

Mesher

The algorithm based on the Finite Quadtree method that automatically creates the finite element mesh.

NFRC

The National Fenestration Rating Council, whose mission is to provide a fair, accurate, and credible rating system for windows and other fenestration products.

Non-contiguous polygons

Polygons that do not share a common edge.

Non-planar surfaces

A surface that has dimensions in more than one plane, i.e., the horizontal and the vertical plane. For example, a greenhouse window has non-planar surfaces.

Nusselt number

The Nusselt number is the ratio of convective to conductive heat transfer. A Nusselt number of 1.0 is an indication of still air.

Overlapping regions

A situation caused when part of one polygon lies on top of another polygon. THERM cannot perform the calculation if this situation exists, and the program tries to prevent it during the drawing process. Sometimes the check for overlapping regions is overly cautious and a warning comes even when an overlap doesn't exist. If this happens you can turn off the "always check for overlapping polygons" option. In general it is best to keep this option turned on when drawing. After the model is completed and the boundary conditions are drawn the program will identify any overlapping regions, which must be corrected before the model can be simulated.

Polygon

A closed shape made up of a minimum of three sides. In THERM, a polygon cannot intersect itself; therefore shapes such as "figure eights" and donuts are not acceptable polygons.

Polylines

A term used in CAD programs to describe a series of line segments connected into a continuous line. A closed polyline in a DXF file can be autoconverted into a polygon by THERM.

Projected length

The dimension obtained by projecting the frame profile on either a horizontal (Projected X) or vertical plane (Projected Y). This value is used as a basis for the U-factor, which is the heat flow per unit temperature difference per unit projected length.

Radiation

The electromagnetic radiation modeled in THERM is the long wavelength thermal radiation that is emitted by opaque bodies at temperatures greater than absolute zero.

Radiation blocking surface

See blocking surface.

Radiation heat transfer

The net energy transfer between two bodies that are radiating to each other. The amount of radiation heat transfer between two bodies depends on the surface emissivities, the radiation view factors and the absolute temperatures of the bodies.

Radiation Model

There are three radiation heat transfer models used in THERM. The detailed radiation model, the curve-fit radiation model and the CEN radiation model. See glossary listings for information on each of these models.

Radiation view-factor

The radiation view-factor is a measure of how much one surface sees of another. A view-factor of 1 means that one surface sees only another surface and nothing else. A view-factor of 0 means that one surface does not see another. Partial viewing will result in a view factor that falls between these extremes. The radiation view factor is calculated by THERM using the cross string method.

Self viewing

The ability of a non-planar product to radiatively see itself. If there is a significant temperature gradient along the surface the radiation heat transfer caused by self-viewing can have a marked effect on the overall heat transfer in the cross section. This is especially true in projecting fenestration products such as greenhouse windows.

Sight line

The point on the room side of the glazing system corresponding to the highest point on the window frame (either exterior or room side). This point is used to determine whether boundary segments on a glazing system are tagged as edge or frame for the U-factor calculation. The height of the edge region is measured from the sight line.

Simulation

The simulation process involves everything necessary for solving the energy equation, including mesh generation, finite element analysis, error estimation, and mesh refinement.

Snap-in pieces

Parts of an assembly that are "snapped" into a main extrusion to create separate cross sections. For example, a window frame head and sill might have a single main extrusion and may differ only in a few snap-in pieces. In THERM the main extrusion could be modeled once, and then cut and paste could be used to model both the head and the sill.

Solar gain

The thermal energy that enters a room through transmission, absorption, and subsequent radiation of solar energy.

Solar Heat Gain Inside Film

The boundary condition that is imported with a glazing system from WINDOW4 corresponding to ASHRAE summer conditions for application to the room side boundary of the glazing system.

Solar Heat Gain Outside Film

The boundary condition that is imported with a glazing system from WINDOW4 corresponding to ASHRAE summer conditions for application to the exterior boundary of the glazing system.

Solid material

An opaque material that is fully defined for analysis purposes by a thermal conductivity and emissivity.

Spacer height

The distance from the top of the spacer to the bottom of the glazing. The height determines the height of the glazing cavity in a glazing system that is imported from WINDOW4. A rectangle the height of the spacer height and a width of the glazing cavity will be left empty when the glazing system is imported. THERM can automatically fill that rectangle with a solid material to approximate a spacer if the **Draw spacer** check box is checked when importing the glazing system.

Step size function

Used in conjunction with the arrow keys to move the cursor a specified amount. Typing in a numeric value defines the step size. Holding down the control key causes the step size to be temporarily decreased by a factor of 10.

Sticky distance

See cursor sticky distance.

Temperature difference

The difference in temperature between the warm and cold sides of a cross section. The temperature difference is the driving force behind conduction, natural convection, and radiation heat transfer.

Thermal bridges

Materials of high thermal conductivity that connect a cold area with a warm area, facilitating heat transfer between these areas.

Thermal conductivity

See Conductivity.

Two-dimensional (2D) conduction heat transfer analysis

An analysis assumption that energy is transported in the horizontal (x) and vertical (y) directions but that nothing is driving the heat flow in the transverse (z) direction.

U-factor

The U-factor is a measure of the heat transfer characteristics of a cross section under specific environmental conditions. In THERM, the U-factor calculation integrates the heat flux over the tagged boundary segment or segments, divides that flux by the projected length of the segment and the defined temperature difference, and returns a U-factor.

U-factor Inside Film

The boundary condition that is imported with a glazing system from WINDOW4 corresponding to ASHRAE winter conditions for application to the room side boundary of the glazing system.

U-factor Outside Film

The boundary condition that is imported with a glazing system from WINDOW4 corresponding to ASHRAE winter conditions for application to the exterior side boundary of the glazing system.

U-factor tags

Labels given to boundary segments over which the heat flow will be integrated in order to obtain U-factors. These boundary segments need not be contiguous nor do they need to be defined with the same boundary condition.

Underlay

A DXF file or a Bitmap file that can be traced over to create the cross-section geometry in THERM.

Vertex (Vertices)

A vertex is a point where two line segments come together in a DXF file or a point on a polygon in a THERM cross section.

Void

An undefined space created between two polygons with unmatched edges. After the model is completed and the boundary conditions are drawn the program will identify any voids. These must be corrected before the model can be simulated.

WINDOW4

A software program developed by the Lawrence Berkeley National Laboratory to calculate center of glass and total window thermal performance indices.

WINDOW4 glass library

The database of glazing layers used to create glazing systems in the WINDOW4 program. This library contains information on the thickness, optical properties, surface coatings and thermal conductivity of the glazing layers.